INVITED TALKS

p-p AND *p-d* SCATTERING AT SMALL ANGLES IN THE RANGE OF 8—70 *GeV*

V. A. Nikitin

The present report is based on papers [1, 2, 3] submitted to this conference.

Measurements of the elastic scattering differential cross section in the range of small four momentum transfers, i. e. in the range of the interference of the nuclear and Coulomb scattering amplitude, enable to determine the value and sign of the real part of the elastic scattering amplitude. The dispersion relation and Regge pole theories as well as the quasi-potential model theory give some predictions for the real part of the scattering amplitude. Therefore it is of great importance to check some of these predictions experimentally.

The experiment was performed at the Serpukhov accelerator. A hydrogen supersonic gas jet was used as a target. An internal proton beam passed through the target many times during an interval of 300 *msec*. The width of the target was about 3 *cm*. The experimental arrangement as well as many details of the method used in this experiment were previously described [4—7]. The scattering angles of recoil particles and their energies were measured by the system of semiconductor detectors.

The incident proton energy was determined by the formula for its dependence on the magnetic field of the accelerator. The proton energy increases at ~ 6 *GeV* during the working interval of the jet target (~ 300 *msec*).

The advantage of the hydrogen jet target can be seen in Fig. 1. Here are plotted two spectra of recoil protons, one obtained in this experiment and the other — in our previous experiment with a thin polyethylene target [4].

A spectrum of recoil deuterons can be seen in Fig. 2. It was obtained using a deuterium gas jet target.

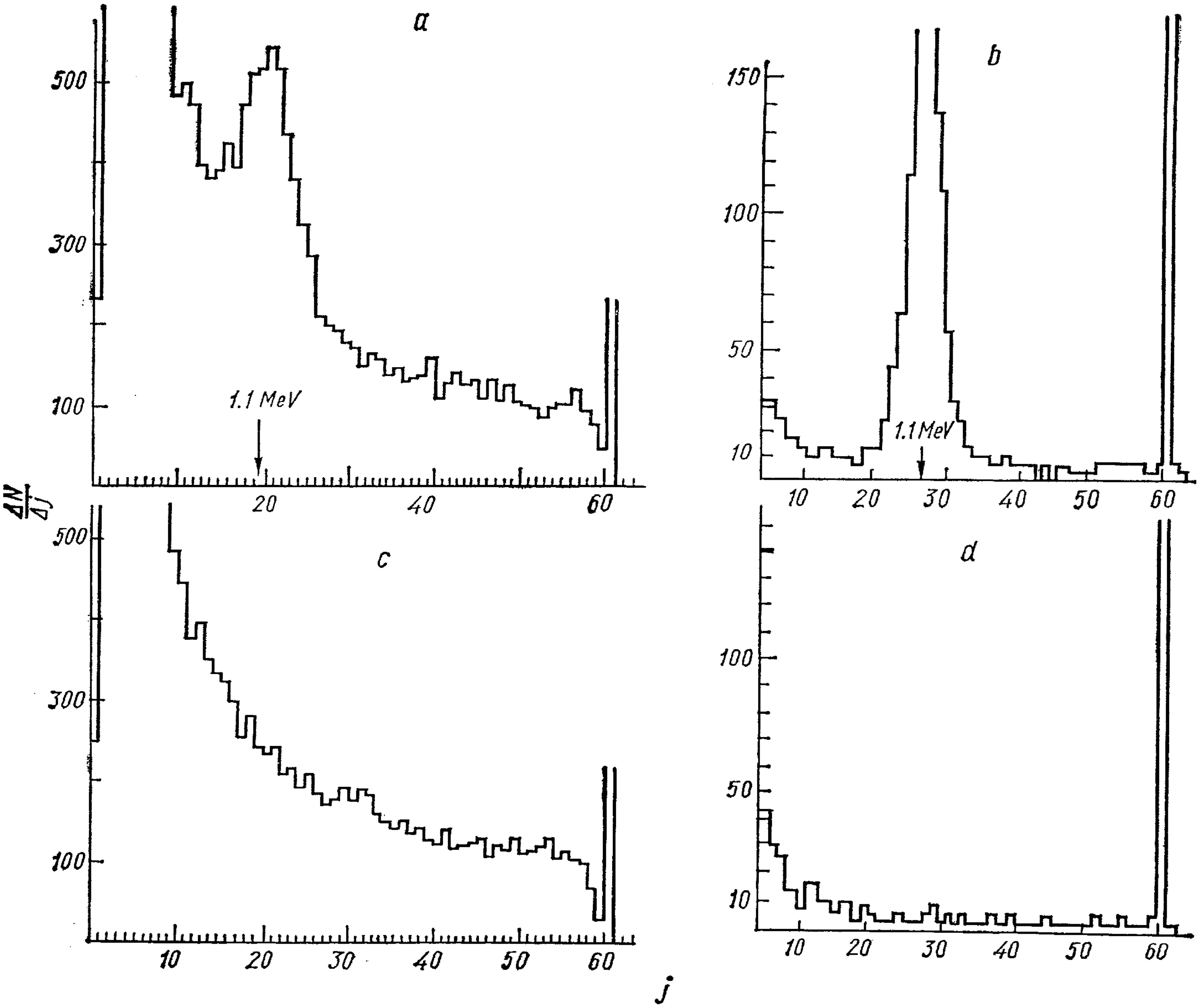

Fig. 1. The spectrum of recoil protons registered by the semiconductor detectors from the thin polyethylene target *a*) and hydrogen jet target *b*); *c*); *d*) are the background spectra, respectively. *j* is the number of the amplitude channel.

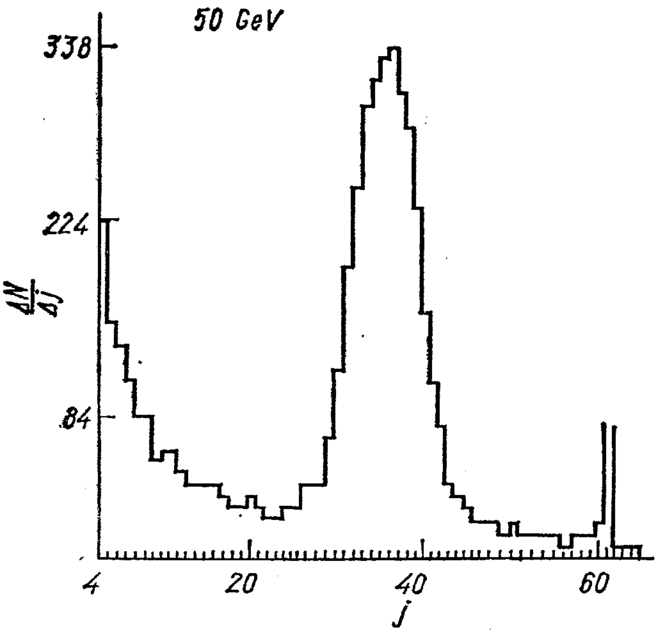

Fig. 2. The spectrum of recoil deuterons obtained from the deuteron jet target at $t = 0.042$ $(GeV/c)^2$.

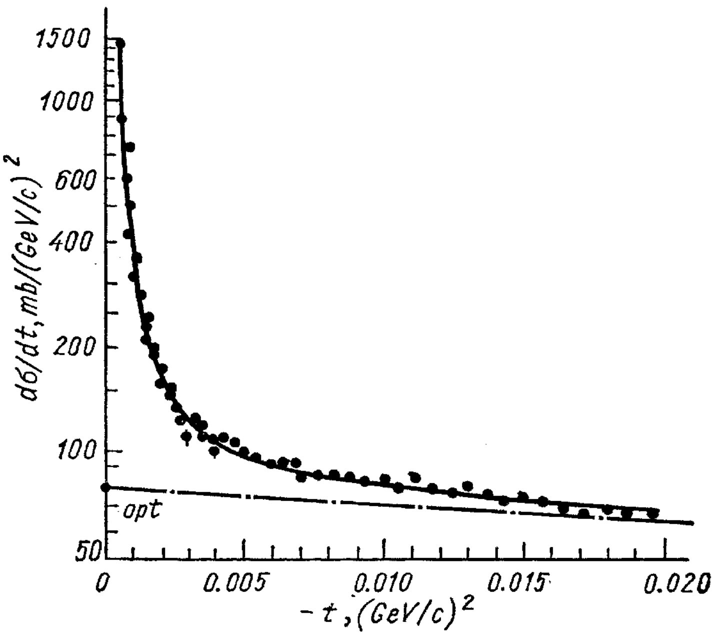

Fig. 3. The differential cross sections of the *p-p* elastic scattering at 70 *GeV*.

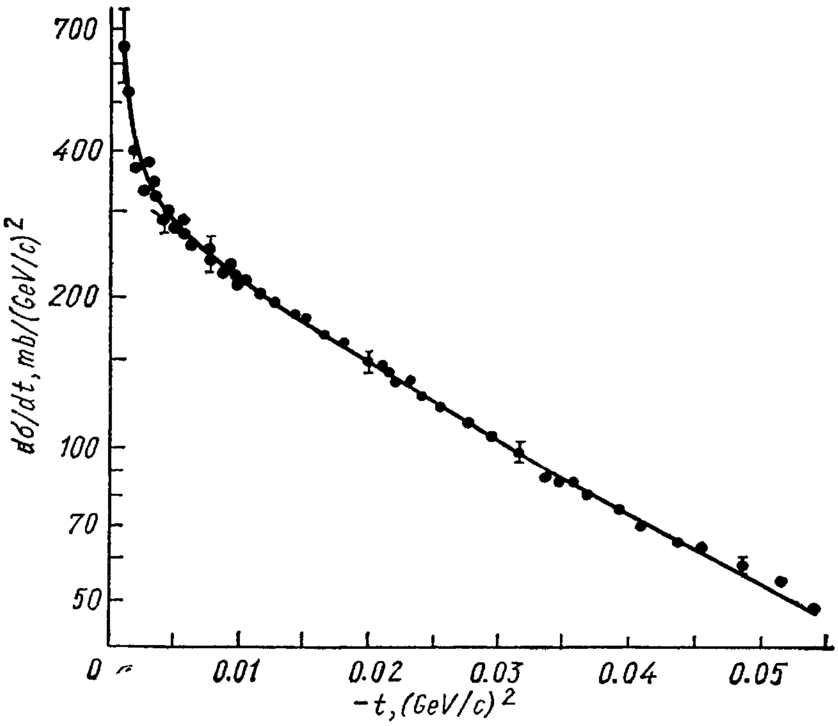

Fig. 4. The differential cross sections of the *p-d* elastic scattering at 34 *GeV*.

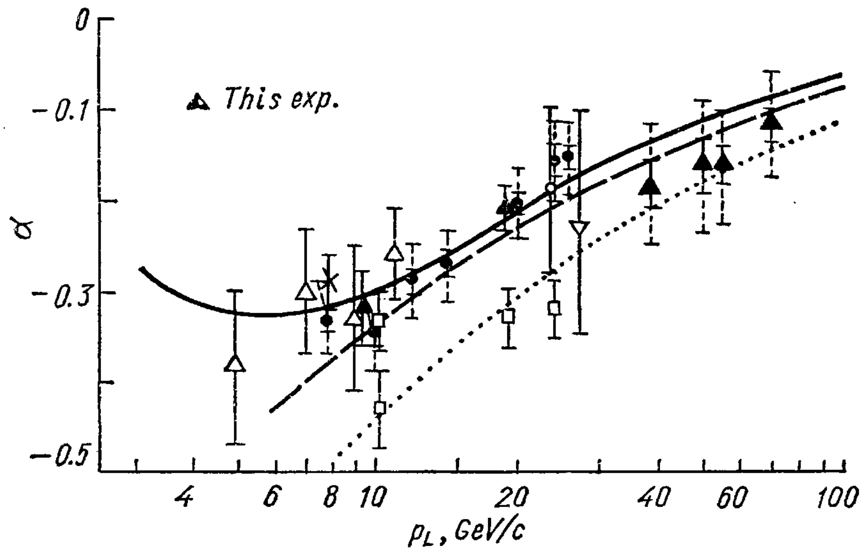

Fig. 5. The ratio α of the real and imaginary parts of the *p-p* elastic forward scattering amplitude plotted against the laboratory momentum of the incident proton. The dotted lines show the possible uncertainty in the present experimental data due to the error in the used value of the total *p-p* cross section ± 1 *mb*. The systematic errors of the data [14] are also indicated by the dotted lines. Theoretical curves: ———— dispersion relations [9]. ------- Regge poles. Experimental data on α [14] is taken into account. .... the same. Data on α do not taken into account [3].

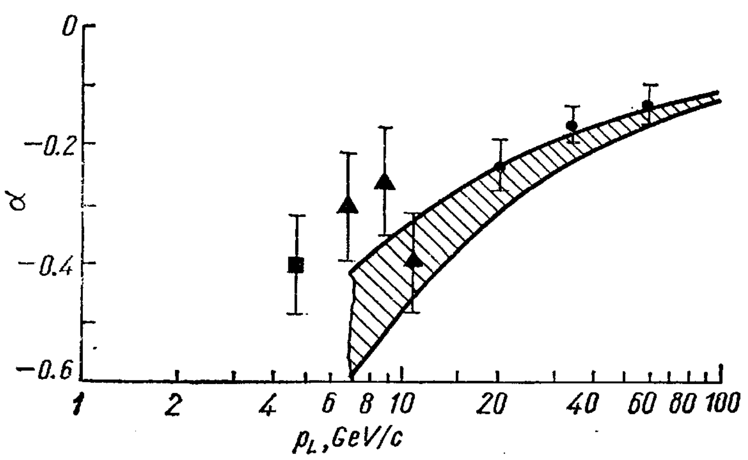

Fig. 6. The ratio α of the real and imaginary parts of the *p-d* elastic forward scattering amplitude plotted against the laboratory momentum of the incident proton. The theoretical dispersion curve from [10] is given here. ▲ N. Dalkhazhav et al. [17]. ■ I. M. Geshkov et al. [19]. ● present data.

The differential cross sections of the p-p and p-d elastic scattering were measured in the small range of the four momentum transfers of $0.001 < |t| < 0.080$ $(GeV/c)^2$.

The differential cross sections of the p-p and p-d elastic scattering in the region of the interference between the Coulomb and nuclear scattering amplitude at 70 *GeV* and 34 *GeV* are shown in Figs. 3 and 4, respectively.

The real part of the p-p and p-d elastic scattering amplitude was determined using the well known Bethe formula without spin dependent terms:

$$\frac{d\sigma}{d|t|} = C\left| A_J^2 + A_r^2 + A_C^2 - 2A_C\left(A_r + 2nA_J \ln\frac{\varphi}{\theta}\right)\right| \qquad (1)$$

where $A_J = \sqrt{\left(\frac{d\sigma}{dt}\right)_{opt}} e^{\frac{1}{2}b_J t}$ is the imaginary part of the p—p elastic scattering amplitude; $A_r = \alpha A_J$ is the real part of this amplitude; b_J is the slope parameter; $A_C = \frac{2nF(t)}{k\theta^2}$ is the Coulomb scattering amplitude; $F(t) = e^{\frac{1}{2}b_J t}$ is the formfactor of the nucleon; $n = \frac{1}{137\beta_{lab}}$; $\varphi = \frac{1,06}{ka}$; $t = -2p_c^2(1 - \cos\theta)$; θ is the scattering angle in the c. m. s.; a is the nucleon radius; p_c and k are the momentum and wave number of the proton in the c. m. s.

The total cross section, which determines the optical point $(d\sigma/dt_{opt}$, is calculated according to the extrapolation formula [14, 16, 18].

$$\sigma_{tot}(pp) = c_0 + c_1 p_{lab}^{-n}$$

$c_0 = 38.25$ *mb*; $c_1 = 16.02$ *mb*; $n = 0.99$. The parameters c and α were determined using the least-square fit to the experimental data. The uncertainty in the quantities $(d\sigma/dt)_{opt}$ and b_J was taken into account. The parameter c, which gives absolute normalization of the differential cross sections, was determined with a typical error of $2 \div 4\%$. The values of α_{pp} and α_{pd} are plotted versus incident proton energies for the p-p and p-d elastic scattering, respectively (Figs. 5 and 6). The dispersion relation calculations [9—10] as well as the experimental data of other papers [11—16] are also shown.

The calculation of α_{pp} is presented in the paper [3] submitted to this conference. The summation of Regge-type diagrams was performed. Many-particle vertices were evaluated taking into account experimental data on pion production. The result is shown in Fig. 5.

The paper [2] by Chernev et al. is devoted to measurements of the p-p and p-d elastic differential cross section in the region of $0.01 < |t| < 0.12$ $(GeV/c)^2$. Some emulsion cameras were exposed at the Serpukhov accelerator for these purposes. An internal film target was used. The installation was the same as in [1, 4, 15, 17]. The slope parameter involving in formula (1) is presented: $b_{pp} = (11.38 \pm 0.27)$ $(GeV/c)^{-2}$ at the incident energy of 50 *GeV*; $b_{pd} = (41.0 \pm 1.1)$ $(GeV/c)^{-2}$ at the incident energy of 70 *GeV*. The new value of b_{pp} is in good agreement with the previous one [4]. It is interesting to compare the new value of b_{pd} with the old one at 10 *GeV* [17]: $b_{pd} = 35.0 \pm 1.0$. The comparison shows a shrinkage of the p-d scattering diffraction cone.

The results of this paper are only a part of our experimental data. The handling of remaining results is continuing.

DISCUSSION

Ter-Martirosyan:

Theoretical curves for the energy dependence of σ_{tot} were obtained considering the Regge pole contribution (P, P', ω, ρ, A_2) and all related branches. The effect of increasing the branch contribution due to the shower production in the intermediate states was taken into account. The number of the parameters chosen is the same that in the Regge pole model as the branch contribution was calculated on the basis of the experimental data on the particle production processes. The attempts were made to shift the curves for σ_{tot} in the high energy region as far upwards as possible, but they showed resistance. We failed to describe the previous data obtained by the Serpukhov — CERN group but, nevertheless, submitted the work to the conference. However, the new dots for $\pi^- p$ given by the Serpukhov group have shifted down and the comparison with them (carried out here in Kiev) showed good agreement.

I should also note that the Regge parameters contributing to the curves for σ_{tot} have reasonable values and well describe all known data on $\pi^{\pm}N$, $K^{\pm} N$ and $N\bar{N}$ elastic scattering as well as $(\mathrm{Re}\, A/\mathrm{Im}\, A)_{t=0}$, the curve $\frac{d\sigma}{dt}$, polarization and the data on charge exchange reactions.

B a d a l y a n:

What is the maximum density of the hydrogen jet you obtained?

N i k i t i n:

The maximum density of the hydrogen jet was $10^{-7}\frac{g}{cm^3}$ and its diameter equals 3 *cm*.

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